NEIL ABERCROMBIE
GOVERNOR OF HAWAII

LORETTA J. FUDDY, A.C.S.W., M.P.H
Director of Health

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HI 96801-3378

In reply, please refer to:
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To: Interested Parties

From: Roger Brewer, Ph.D., Environmental Risk Assessor, HEER

Subject: *Screening for Environmental Hazards at Site with Contaminated Soil and Groundwater*, Fall 2011 Updates

This technical memorandum summarizes updates to Environmental Action Levels (EALs) published by the Hazard Evaluation and Emergency Response (HEER) office of the Hawaiʻi Department of Health (HDOH). The background and development of the EALs is described in the HEER office guidance *Screening for Environmental Hazards at Site with Contaminated Soil and Groundwater* ("EHE" guidance; HDOH 2011). The Fall 2011 updates replace and take precedence over earlier editions of the EALs.

A detailed review of revisions to the 2009 EALs is provided in the attachment to this memorandum and in the appendices of the updated EHE guidance. Significant revisions to the EALs include:

- Soil action levels presented in EAL Surfer for **dioxins** revised to reflect June 2010 updates (HDOH 2010a);
- Reference to October June 2010 update of categories for **arsenic** contaminated soil added to Surfer notes box (HDOH 2010b);
- Soil action levels for **aldrin and dieldrin** revised to reflect higher confidence in noncancer studies and common co-occurrence in termiticide-treated soil in the absence of other chemicals (final Tier 1 soil action levels increased);
- Target noncancer Hazard Quotient for **thallium** adjusted to 1.0 to help take into account natural background presence of thallium in soil;
- Inhalation toxicity factor (Reference Concentration) and target risk for **"TPH" in indoor air and soil gas** revised based on soil gas study carried out by HEER office (increased TPH soil gas action level for vapor intrusion hazards);
- **Physiochemical constants** for chemicals updated to reflect change in USEPA Regional Screening Level guidance (HDOH EALs not significantly affected);
- **Sorption coefficient** used to define "low-mobility chemicals" revised downward from 30,000 cm^3/g to 5,000 cm^3/g (final Tier 1 action levels for several **PAHs** and **organochlorine pesticides** increased to more appropriately reflect direct-exposure action level, rather than leaching based action level);
- Alternate Volatilization Factor (estimates vapor emissions from soil) that takes into account poor air flow in trenches used to calculate **VOC soil action levels for trench**

and construction workers (USEPA 2002, see Appendix 2). Reduced previous action levels by a factor of approximately four.

- Updates to **background metals in soils** added (see Appendix 1, Section 7);
- Soil ecotoxicity action levels eliminated (increase in action levels for some **metals** to reflect direct exposure action levels, rather than generic, ecotoxicity based action levels);
- Aquatic (and associated groundwater) **acute toxicity action levels for PAHs** updated to reflect generic action level for PAHs (increased some groundwater action levels).
- Additional discussion on development of **Tier 1 vs Site-Specific Soil Action Levels** provided (Volume 1, Section 4.1);
- Additional discussion of site-specific evaluation of **leaching of contaminants from soil** (Volume 1, Section 4.3.3 and Appendix 1, Section 4.4);
- Additional discussion on distinguishing **background levels of VOCs in indoor air** from vapor intrusion added (Volume 1, Section 4.5);
- Expanded discussion of **vapor intrusion models and action levels** included in Appendix 1, Chapter 2;
- HDOH technical memorandum discussing the natural occurrence of **hexavalent chromium in groundwater** added to Appendix 8;
- Note regarding the presence of apparently natural, **background lead in caprock sediment groundwater** above action levels added to Volume 1, Section 4.3);
- **EAL Surfer** updated.

A summary of the more significant changes to the 2009 Tier 1 EALs is provided in Table 1 (organochlorine pesticides), Table 2 (metals) and Table 3 (Total Petroleum Hydrocarbons in soil gas). Groundwater action levels were not affected in this update of the EALs. These updates reflect site-specific studies carried out in Hawai‘i by HEER staff and environmental consultants since publication of the 2009 EHE guidance. This includes reviews of toxicity factors, soil batch tests for evaluation of leaching hazards, carbon range soil gas data from petroleum-contaminated sites and background metal concentrations in soils. Separate reports on background metals in soils and the measurement, chemistry and toxicity of petroleum vapors in soil gas are to be published separately by the HEER office.

The EHE document and associated EALs will be revised and updated on a regular basis. Comments and suggestions from the general public are welcome at any time. Updates will be posted to the HDOH EHE website and notification sent to persons on the EHE mailing list. Workshops to present and discuss the EALs will also be held periodically. To provide comments or be included on the mailing list for updates and workshop announcements, please contact:

Roger Brewer
Hawai’i Department of Health
Hazard Evaluation and Emergency Response
Telephone: 1-808-586-4328
E-mail: roger.brewer@doh.hawaii.gov

Table 1. Updates to Tier 1 EALs for Organochlorine Pesticides (2009 EAL noted in parentheses).

Chemical	Groundwater IS a Potential Source of Drinking Water (mg/kg)		Groundwater is Not a Potential Source of Drinking Water (mg/kg)	
	Surface Water <150m	Surface Water >150m	Surface Water <150m	Surface Water >150m
ACENAPHTHENE	120 (20)	120 (20)	120 (23)	140 (140)
ALDRIN	0.92 (0.029)	0.92 (0.029)	0.92 (0.029)	0.92 (0.029)
ANTHRACENE	4.3 (2.5)	4.3 (2.5)	4.3 (2.5)	4.3 (2.5)
BIPHENYL, 1,1-	10 (0.52)	10 (0.52)	10 (5.2)	10 (5.2)
DIELDRIN	1.5 (0.003)	1.5 (0.007)	1.5 (0.003)	1.5 (0.03)
ENDOSULFAN	18 (0.032)	18 (0.12)	18 (0.032)	18 (0.12)
ENDRIN	3.7 (0.004)	3.7 (0.06)	3.7 (0.004)	3.7 (0.06)
FLUORENE	100 (7.3)	130 (130)	100 (7.3)	130 (130)
HEPTACHLOR EPOXIDE	0.053 (0.003)	0.053 (0.046)	0.053 (0.003)	0.053 (0.046)
PHENANTHRENE	69 (11)	69 (18)	69 (11)	69 (18)
TRIFLURALIN	24 (14)	24 (14)	54 (32)	54 (32)

Table 2. Updates to Tier 1 EALs for Metals.

Chemical	Residential			Commercial/Industrial		
	2009 (mg/kg)	2011 (mg/kg)	2011 Basis	2009 (mg/kg)	2011 (mg/kg)	2011 Basis
ANTIMONY	6.3	6.3	DE	40	82	DE
ARSENIC (total)	20	*24	BG	20	*24	BG
BARIUM	750	1,000	GC	1,500	2,500	GC
BERYLLIUM	4.0	31	DE	8.0	150	DE
CADMIUM	12	14	DE	12	120	BG
CHROMIUM (Total)	500	*1,100	BG	500	*1,100	BG
CHROMIUM III	750	*1,100	BG	750	*1,100	BG
CHROMIUM VI	8.0	29	DE	8.0	480	DE
COBALT	40	180	DE	80	180	DE
COPPER	230	626	DE	230	2,500	DE
LEAD	200	200	DE	800	800	DE
MERCURY	4.7	4.7	DE	10	61	DE
MOLYBDENUM	40	78	DE	40	1,000	DE
NICKEL	150	760	DE	150	870	DE
SELENIUM	10	78	DE	10	1,000	DE
SILVER	20	78	DE	40	1,000	DE
THALLIUM	1.0	0.78	DE	13	10	DE
VANADIUM	110	*770	BG	200	1,000	DE
ZINC	600	1,000	GC	600	2,500	GC

DE: Direct Exposure; BG: Background; GC: Gross Contamination. *Estimated Upper Bound of naturally occurring metal in volcanic soils. Natural background concentration may be higher in some areas. Thallium action level may be below natural background in some areas (likely to be natural background if detected and no known, past releases of thallium salts at site). Background metals likely to be lower in carbonate-rich, coast sediments and soils. Compare soil data for vanadium directly to direct-exposure action levels if a release of one or more of these metals is known to have occurred in carbonate-rich, coastal soils.

Table 3. Updates to TPH soil gas action levels.

Chemical	Reference Concentration (ug/m^3)		Soil Gas Action Level (ug/m^3)			
			2009		2011	
	2009	2011	Residential	Commercial/ Industrial	Residential	Commercial/ Industrial
TPH(gasolines)	50	225	26,000	73,000	230,000	660,000
TPH(middle distillates)	110	225	57,000	160,000	230,000	660,000

TPH = Total Petroleum Hydrocarbons; middle distillates includes diesel fuels.

ATTACMENT

Technical Overview of Fall 2011 Updates to 2009 HDOH/HEER Tier 1 EALs

HDOH 2011, *Screening for Environmental Hazards at Sites with Contaminated Soil and Groundwater* (December 2011), Hawai'i Department of Health, Hazard Evaluation and Emergency Response, http://hawaii.gov/health/environmental/hazard/index.html

1. Adjustment of target risk and soil action levels for aldrin and dieldrin. Soil action levels for aldrin and dieldrin revised to reflect higher confidence in noncancer studies. Updated action levels are noted in Table one of the cover memo. Aldrin was sometimes used as an alternative to Technical Chlordane as a termiticide for treatment of soil around and under wooden structures. Dieldrin is a breakdown product of aldrin. The target noncancer Hazard Quotient for each chemical was adjusted to 0.5, based on the common co-occurrence in termiticide-treated soil in the absence of other chemicals and a target, cumulative Hazard Index of 1.0. The target cancer risk was adjusted upwards to 10^{-4}.

Cumulative risk should be evaluated if other contaminants are identified in the soil at concentrations that approach or exceed their respective, direct-exposure action levels (e.g., Technical Chlordane). Lead in the soil around structures (e.g., from lead-based paint) should be evaluated separately.

2. Residential Soil Action Level for Lead. The 2009 Tier 1 soil action levels for lead in residential soils ("Unrestricted" land use) was 200 mg/kg. This was based on a published, plant toxicity screening level in soil (see Appendix 1, Table A and B series in 2009 document). An action level of 400 mg/kg was presented in the document for residential, direct-exposure hazards. This action level was based on a "Preliminary Remediation Goal (PRG)" (more recently referred to as the "Regional Screening Level (RSL)") published by the USEPA in the 1990s and still presented in their 2011 RSL guidance (USEPA 2011a).

The USEPA PRG/RSL is intended to reflect a maximum, target lead blood level in children of 10 ug/dl. Recent USEPA guidance recommends reduce this target level be reduced to 5 ug/dl (USEPA 2011b). In order to reflect this change, the residential direct-exposure soil action level for lead in this update of the HEER EHE guidance has been reduced from 400 mg/kg to 200 mg/kg. This is intended to serves as an interim action level until such time that the USEPA PRG for lead in soil is formally updated. Note that the final Tier 1 soil action level for lead remains unchanged at 200 mg/kg, even though the 2009 soil ecotoxicity action level for lead of 200 mg/kg has been dropped (see note Number 5). The commercial/industrial soil action level for lead of 800 mg/kg was not changed (based on USEPA commercial/industrial PRG/RSL).

3. Update of chemical sorption coefficients. Sorption coefficients (koc) presented in Appendix 1, Table H of the EHE guidance were updated to reflect revisions to generic koc values used in the June 2011 edition of the USEPA Regional Screening Levels guidance (USEPA 2011a). Coefficients used in the 2009 EALs were based on an earlier edition of the same guidance. Sorption coefficients are included in models used to generate soil action levels for direct exposure, vapor intrusion and leaching hazards. The updates to the sorption coefficients resulted in only minor changes to the soil action levels.

4. Default sorption coefficient (koc) used to define "low mobility" chemicals in soil leaching models reduced from 30,000 cm^3/g to 5,000 cm^3/g. Sorption coefficients (koc) are use to estimate how strongly a chemical will bind to organic carbon in soil and are a key component of soil leaching models. Chemicals with low sorption coefficients, like MTBE (11 cm^3/g) and PCE (95 cm^3/g) are highly mobile and a significant proportion of the chemical will preferentially dissolve into pore water and leachate, posing a potential threat to underlying groundwater. Published koc values are multiplied y the assumed organic carbon content of the soil to calculate an adjusted, “Kd” coeffiecient for modeling (e.g., Kd = koc x 0.2% organic carbon). Chemicals with high sorption coefficients, like PCBs (131,000 cm^3/g) and chlordane (87,000 cm^3/g) will become tightly bound to soil particles and relatively immobile in soil. These chemicals do not pose significant risk to groundwater unless pure product manages to reach the water table.

The approach used to develop soil action levels for potential leaching hazards is discussed in Appendix 1 of the EHE guidance. A generic algorithm is used develop action levels for chemicals with an assumed moderate to high mobility. Chemicals with a sorption coefficient greater than 30,000 gm/cm^3 were considered to be very low mobility and not a significant threat to groundwater. Leaching based soil action levels were set at that chemicals theoretical saturation limit in soil (i.e, the maximum amount of the chemical that could be sorbed onto soil particles or dissolved in pore water before free product began to appear).

In 2007 the HEER office published guidance on the use of laboratory “batch tests” to more accurately evaluate the leachability of chemicals in soil on a site-specific basis (HDOH 2007). The specific batch test used is referred to as the Synthetic Precipitation Leaching Parameter or “SPLP” test. The test can be used to directly measure the Kd sorption coefficient (or more accurately a *desorption* coefficient) for a chemical in the soil rather than relying on generic factors and assumed soil properties, as done for the soil action levels.

Since 2007 time batch test data have consistently indicated that aged-chemicals in soil are much less mobile and pose a much lower threat to groundwater than the generic sorption coefficient and associated action levels would otherwise suggest. A significant number of batch test have in particular been carried out on soil contaminated with organochlorine pesticides, such as chlordane, dieldrin and aldrin. These tests suggest that the published sorption coefficients and generic leaching model used *over predict* contaminant mobility and potential impacts to groundwater by at least an order of magnitude.

Examples of default versus measured sorption coefficients from studies in Hawai‘i are provided below (measured as “Kd,” see HDOH 2007). A Kd value greater than 20 indicates that the chemical is essentially “immobile.”

Chemical	**[1]Published Koc Value (cm^3/g)**	**[2]Modeled Kd Value (cm^3/g)**	**[3]Measured Kd Value (cm^3/g)**
Assumed Moderate- to High-Mobility Chemicals			
[4]Ametryn	450	0.45	30
[4]Atrazine	230	0.23	6.9
[6]Benzene	170	0.17	8.4 to 203
[7]Dieldrin	11,000	11	650-690
[4]Diuron	136	0.14	86

[4]Trifluralin	9,680	9.7	5,000
Assumed Low-Mobility Chemicals			
[7]Aldrin	106,000	106	5,800-6,600
[5]Arsenic	(not applicable)	29?	2,100 to 19,000
[8]Chlordane	87,000	87	4,200-7,800
[4]Dioxins	257,000	257	10,000-51,000

1. Default koc value used in leaching models (from USEPA 2011a); refer to EHE guidance Appendix 1, Table H (HDOH 2011).
2. Calculated Kd used in EAL soil leaching model = koc x assumed Total Organic Carbon fraction of 0.001.
3. Based on results of SPLP batch test for soil samples collected at the noted site (HDOH 2007).
4. *Site Investigation Report and Environmental Hazard Evaluation, East Kapolei II Pesticide Mixing and Loading Site*, Enviroservices & Training Center, LLC, March 2010.
5. *Remedial Alternatives Analysis & Response Action Report*, Former Ka'u Agribusiness, ASCI-ERM, November 2008. Leaching based soil action levels for arsenic not included in EHE guidance; site-specific batch test data require. Noted Kd from USEPA SSL and RSL guidance (USEPA 1996, 2011a).
6. *Remedial Investigation Report, Former GASCO Facility*, Weston Solutions, April 1, 2009.
7. *Results of Leachability Testing for Organochlorine Pesticides in Soil using the Synthetic Precipitation Leaching Procedure, Earhart I-4 Neighborhood, Hickam Air Force Base, Hawai'i*, Tetra Tech, December 18, 2009.
8. *Removal Action Plan and Environmental Hazard Evaluation, Ironwoods at Kailua*, Tetra Tech EM, Inc., July 18, 2011 (draft).

As can been seen from the table, soil action levels calculated using generic sorption coefficients and assumed Kd values tend to significantly over predict the mobility of the chemical in soil. Although not routinely measured, organic carbon in the soils is typically 1% or less and does not by itself explain the increased Kd value. The higher Kd value is instead most likely associate with secondary sorption onto or diffusion into clays, as well as an increased difficulty in *desorption* of an aged chemical in soil from organic carbon.

Based on soil SPLP batch test data collected in Hawai'i the default sorption coefficient (koc) used to define "low mobility" chemicals in soil leaching models was reduced from 30,000 cm^3/g to 5,000 cm^3/g. The theoretical soil saturation concentration is then used as the default leaching based soil action level for potential leaching hazards for all chemicals with a published koc that exceeds this value. This has proven to be a useful approach to verifying the leachability of presumed low-mobility chemicals in soil. This significantly increased the leaching based action levels for several chemicals, especially PAHs and organochlorine pesticides. Chemicals affected include: Acenaphthene, Anthracene, 1,1 Biphenyl, Endosulfan, Endrin, Fluorene, Heptachlor, Heptachlor Expoxide, Phenanthrene, Trifluralin. The following table summarizes the changes in the 2009 versus 2011 action levels (2009 action level noted in parentheses):

	Groundwater IS a Potential Source of Drinking Water		**Groundwater is Not a Potential Source of Drinking Water**	
***Chemical**	**Surface Water <150m**	**Surface Water >150m**	**Surface Water <150m**	**Surface Water >150m**
ACENAPHTHENE	120 (20)	120 (20)	120 (23)	170 (200)
ANTHRACENE	4.3 (2.5)	4.3 (2.5)	4.3 (2.5)	4.3 (2.5)
BIPHENYL, 1,1-	210 (0.52)	210 (0.52)	210 (5.2)	210 (5.2)
DIELDRIN	30 (0.003)	30 (0.007)	30 (0.003)	30 (1.2)
ENDOSULFAN	18 (0.032)	18 (0.12)	18 (0.032)	18 (0.12)
ENDRIN	30 (0.004)	30 (0.07)	30 (0.004)	30 (0.07)
FLUORENE	100 (7.3)	370 (460)	100 (7.3)	460 (560)

HEPTACHLOR EPOXIDE	12 (0.003)	12 (0.046)	12 (0.003)	12 (0.046)
PHENANTHRENE	69 (11)	69 (18)	69 (11)	69 (18)
TRIFLURALIN	24 (14)	24 (14)	54 (32)	54 (32)

*Chemicals listed in the EHE guidance with a koc value between 5,000 and 30,000 cm^3/g. *Reduction* of some action levels (e.g., fluorine) reflects a significant *reduction* of the published koc value used in the model, based on updates to the USEPA RSLs. This offset use of the alternative saturation model.

These changes are reflected in Table 1 in main technical memorandum. Note that a lower action level in Table 1 than presented above reflects use of the direct-exposure action level over leaching based action level for final, Tier 1 EAL. The above table only summarized changes to leaching based soil action levels, while Table 1 comprehensively summarizes changes to all categories of action levels and presents the lowest. Site-specific SPLP batch tests are recommended in cases where the saturation level is exceeded (see HDOH 2007).

5. Naturally occurring, background levels of metals in soil updated. The HEER office undertook a review of background concentrations of metals in soil in 2011 (to be published in late 2011 or early 2012). The estimated Upper Bound concentration of metals in volcanic soils was incorporated into Appendix 1 of the EHE guidance for consideration in selection of final, Tier 1 EALs. Updated action levels are noted in Table 2 of the cover memo. Target noncancer Hazard Quotient for **thallium** adjusted to 1.0 to help take into account natural background and lack of available soil data.

The Background Threshold Value noted in Table 2 reflects the maximum-reported concentration of the metal in the samples compiled for the study. *Higher* concentrations are possible in volcanic soils due to localized, metal-rich volcanic deposits or due to testing of small aliquots of discrete soil samples with non-representative nuggets of metal-rich, iron hydroxides.. Background metals likely to be *lower* in carbonate-rich, coast sediments and soils. Compare soil data for nickel, thallium and vanadium directly to direct-exposure action levels if a release of one or more of these metals is known to have occurred in carbonate-rich, coastal soils.
Naturally occurring trace metals in the volcanic and caprock soils of Hawai‘i are not significantly bioavailable and do not pose a risk to human health. Similar trace metals are used in the production of steel and other alloys. With perhaps the exception of lead, these trace metals *will not be released to soil in a bioavailable form* upon use or even degradation (e.g., rusting) of metallic objects (e.g., tanks, heavy equipment, etc.). Toxicity factors and associated, risk-based soil action levels are likewise based on soluble, highly bioavailable forms of these metals (e.g., thallium salts). *The soil action levels do not apply to metals in soil likely to be associated with natural background or degraded, metallic objects.*

6. Soil ecotoxicity action levels discontinued. The use of generic, published soil action levels for terrestrial ecotoxicity has always been contentious issue, due to site-specific differences in soil type and more importantly pertinent, ecological receptors. An internal HEER review also indicated that naturally occurring concentrations of metals in the iron-rich, volcanic sols of Hawai‘i often exceed generic, ecotoxicity soil screening levels developed for use in soils more typical of granitic, continental geologic settings (to be published in 2011or 2012). In Hawai’i these metals are tightly bound to soil particles (e.g., iron hydroxides) and not significantly toxic. This negates the use of generic screening levels developed outside of the state. Site-specific assessment will instead be required in rare cases where a sensitive ecohabit is present.

7. Childhood Adjustment Factor deleted from vapor intrusion models. Earlier editions of the USEPA Residential Preliminary Remediation Goals (PRGs, 2004 and earlier) included a "Childhood Adjustment Factor" of 0.791 for indoor air PRGs (carcinogens only; reduced initially calculated goal by approximately 20%). This adjustment factor was incorporated into HEER EAL models used to generate indoor air, soil gas, soil and groundwater action levels for vapor intrusion (not shown in Appendix 2 Indoor Air action level equations). Use of the adjustment factor was discontinued in post-2004 updates of the USEPA PRGs due to the already conservative nature of the model assumptions (now referred to as Regional Screening Levels; see USEPA 2011). Eliminating the adjustment factor increased indoor air, soil gas, soil and groundwater residential action levels by approximately 20% in the Fall 2011 update of the EHE guidance.

8. Tapwater risk-based action levels corrected to only consider inhalation of vapors during showering for volatile chemicals (action levels not significantly affected.

9. Noncancer RfC for TPH revised based on carbon range data for soil gas samples collected at petroleum release sites (same RfC used for both gasolines and middle distillates. Target noncancer Hazard Quotient revised to 1.0, based on overwhelming predominance of non-BTEX/PAH, "TPH" compounds in petroleum vapors. TPH soil gas action levels significantly increased. Refer to accompanying EAL update memo for details (HDOH 2011).

TPH: Expand on RfCs & NCEA toxicity factors, soil gas carbon range data. Note current TO-17 study and pending updates to soil gas sample collection data. Note that field methods for the collection of soil gas samples presented in the HEER office Technical Guidance Manual are currently being revised.

Use To method to determine TPH in soil gas. Current carbon range approaches do not adequately quantify TPH in soil gas. Use site-specific carbon range makeup

References:

HDOH, 2007, *Pesticides in former agricultural lands and related areas - Updates on investigation and assessment* (May 11, 2007): Hawai'i Department of Health, Solid & Hazardous Waste Branch, www.hawaii.gov/health/environmental/hazard/eal2005.html.

HDOH, 2010a, Update to Soil Action Levels for TEQ Dioxins and Recommended Soil Management Practices (June 2010): Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response, http://www.hawaiidoh.org/

HDOH, 2010b, Update to Soil Action Levels for Inorganic Arsenic and Recommended Soil Management Practices (October 2010): Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response, http://www.hawaiidoh.org/

HDOH 2011, *Screening For Environmental Hazards at Sites With Contaminated Soil and Groundwater* (Fall 2011), Hawai'i Department of Health, Hazard Evaluation and Emergency Response, http://hawaii.gov/health/environmental/hazard/index.html

TetraTech, 2011, *Report for the Hawaii Department of Health on Aldrin/Dieldrin Concentrations in Soil at the Hickam Air Force Base* (April 5, 2011): Tetra Tech Corporation, 130pp (available from HDOH, HEER office).

USEPA, 1996a, *Soil Screening Guidance: Technical Background Document*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Publication 9355.4-17A, May, 1996.

USEPA, 2002, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*: U.S. Environmental Protection Agency, Solid Waste and Emergency Response, OSWER 9355.4-24, December 2002, http://www.epa.gov/superfund/resources/soil/ssg_main.pdf

USEPA, 2011a, Screening Levels for Chemical Contaminants: U.S. Environmental Protection Agency, May 2008 (updated June 2011), prepared by Oak Ridge National Laboratories, http://www.epa.gov/region09/waste/sfund/prg/

USEPA, 2011b, OPPT Program-Specific Regional Offices Priorities, Lead Risk Reduction Program (update): U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, *in* National Program Manager Guidance Final, FY 2012, EPA-740-B-11-001, http://www.epa.gov/planandbudget/annualplan/FY12_OCSPP_NPM_Gdnce.pdf